AN ASSESSMENT OF AIR FORCE DEVELOPMENT PORTFOLIO MANAGEMENT PRACTICES

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Selecting and managing development project portfolios is a critical function within the Air Force's weapon systems development process. Decision makers must weigh benefits, costs, and mission needs for a variety of proposed new initiatives and current weapon systems programs in order to develop an effective portfolio that provides the best value to the User. This research examines current Air Force development portfolio management practices as perceived by those involved with the decision making process. Research findings indicate several gaps between Air Force practices and those commercial best practices as found in the literature. A general approach for bridging the differences is offered as recommendations.

With an annual research, development, test, and evaluation (RDT&E) budget of $37.9 billion, and an additional $60.3 billion allocated toward weapon systems procurement in fiscal year 2001, the Department of Defense (DoD) spends more on weapon systems development and procurement than any other organization in the world spends on new product development (NPD) (DoD, 2000a).

Of this $98.2 billion, $9.7 billion in RDT&E funds and $14.1 billion in procurement funds were appropriated specifically for Air Force weapon systems development and procurement. While staggering at first glance, today's weapon systems development budget has only recently stabilized after more than a decade of reduction in spending.

Measured in constant fiscal year 2001 dollars, DoD RDT&E spending has decreased nearly 18 percent while procurement spending has been cut 56 percent over the last 16 years (DoD, 2000b). This constrained resources environment has been a major driver behind resurgent acquisition reform efforts. Overarching Air

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
2002		**00-00-2002 to 00-00-2002**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
An Assessment of Air Force Development Portfolio Management Practices	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Air Force Institute of Technology,Wright Patterson AFB,OH,45433**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES
Acquisition Review Quarterly, Spring 2002

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			
unclassified	**unclassified**	**unclassified**	**Same as Report (SAR)**	**26**	

Force efforts include, but are not limited to, the introduction of acquisition reform Lightning Bolts, the implementation of acquisition reform initiatives (Lean Aerospace Initiative [LAI], Cycle Time Reduction, Cost as an Independent Variable [CAIV], Reduction in Total Ownership Costs [R-TOC], and Single Process Initiative [SPI]), and the establishment of reinvention teams.

Identifying and analyzing commercial NPD and development portfolio management best practices has been the subject of many research efforts (Calantone et al., 1995; Cooper et al., 1995, 1998a, 1998b, 1999, 2000; Griffin, 1997; Gupta et al., 2000; Lester, 1998; Poolton & Barclay, 1998; Scott, 2000). To date, these efforts have focused solely on commercial industry practices.

The objective of this research is to, for the first time, shift the focus from the commercial sector to that of military weapon systems development. Specifically, this research examines the current state of Air Force development portfolio management processes, where the development portfolio is defined as a grouping of weapon systems development projects by either a common functionality or a common mission area.

Issues of Complexity and Uniqueness

In the weapon systems development environment, the operation of a sound development portfolio management process is imperative and is an endeavor that comes with challenges unique to those found in the commercial sector. For example, economic measures including increased profits, revenue generation, increased market share, and increased shareholder value represent some of the more common measures of NPD success in commercial industry.

However, success in weapon systems development cannot easily be measured in economic terms and success criteria are often more qualitative in nature. Other unique aspects of weapon systems development include the importance and development of military strategy, the synergistic nature of weapon systems, political oversight of the process, and the resource allocation process. These issues are not mutually exclusive; instead, there is significant overlap and interaction between these four areas of complexity and uniqueness. For example, issues of political oversight add to the complex nature of military strategic planning as well as the resource allocation process. The following comments regarding these issues are presented with an Air Force perspective.

Strategy

Strategic planning is a key element within the DoD. Weapon systems development plays a crucial role in determining strategic goals, objectives, and the direction of U.S. policy. Successful weapon systems employment provides U.S. leaders with options in enforcing both domestic and international policy. The ability to gauge today's environment, both domestic and internationally, and predict trends 10, 15, or even 20 years in the future is no easy task. Entire directorates exist whose sole charter is to conduct strategic planning activities. Strategic plans and policies emerge only after thorough analysis of international and domestic threats, potential technological breakthroughs, and determin-

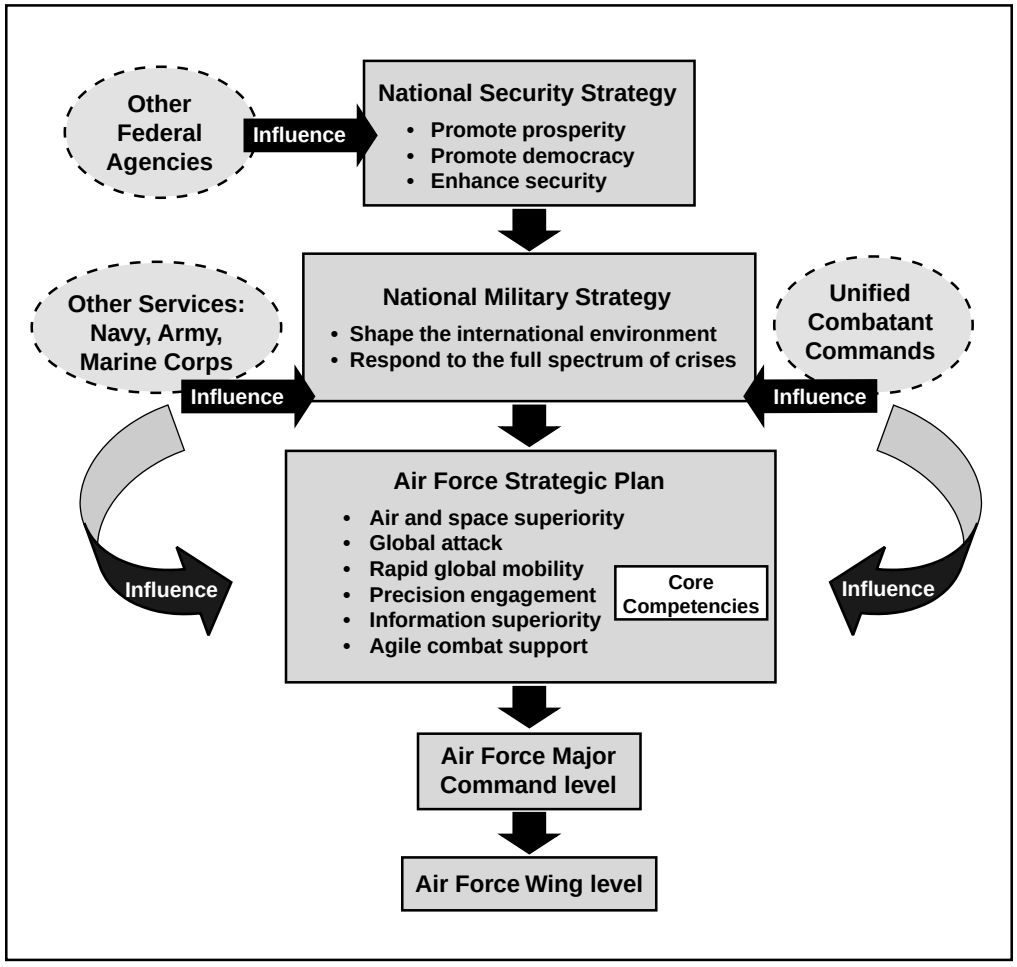

Figure 1. National Security Strategy Flow

ing the presence the United States will have on global affairs.

The hierarchical flow of strategy development is presented in Figure 1. At its highest level, national security strategy is developed, which flows to the DoD. At the DoD level, a joint service view of how to support the national security strategy is developed. From there, each service is empowered to construct strategic plans and policies that support the DoD joint service perspective, eventually providing support to the national security strategy (DoD, 2000c).

Figure 1 provides insight into the complex nature of this process. Each level of strategic planning introduces the opportunity for differences in interpretation. Additionally, at each level, the coordination of multiple participants becomes increasingly difficult. For example, the DoD is not alone in providing support of the national security strategy. Agencies such as the Department of Energy, the Central

Intelligence Agency, and the Department of State are all involved with national security issues. At lower levels, bringing together the Army, Navy, Marine Corps, and Air Force leadership to develop synergistic plans effectively can itself become a politically charged endeavor.

Synergistic Nature of Weapon Systems

Another aspect that distinguishes weapon systems development from its commercial counterparts is the synergistic nature of these systems. In the modern-era of warfare, never has one of the three components (air, sea, or land) been able to achieve predetermined strategic objectives alone; the most recent examples being Operation Desert Storm and the conflict in former Yugoslavia. In both cases, the ability to synergize the capabilities of the Army, Navy, Marine Corps, and Air Force provided the U.S.-led coalition with the overarching capability to conduct overwhelmingly dominant activities against its adversaries.

"The historic portrayal of military conflict as a two-dimensional environment, where generals direct the war using a game board representation of the battlefield, is long outdated."

The historic portrayal of military conflict as a two-dimensional environment, where generals direct the war using a game board representation of the battlefield, is long outdated. Today's battlefield is an orchestration of air, ground, sea, and space assets, all integrated and connected by vast communications and information dissemination networks that form the backbone of such a synergistic battlefield. One of the key components of the Joint Vision 2020 document is the ability for weapon systems, and U.S. forces in general, to integrate with each other. Joint Vision 2020 (DoD, 2000d) defines interoperability as the "ability of systems, units, or forces to provide services and accept services from other systems, units, or forces and to use the services so exchanged to enable them to operate effectively together" (p. 15).

While commercial practices lean toward using common components and common platforms, the requirement to integrate with other commercial systems is much less imperative than this requirement in a weapon systems environment. For example, if Ford discontinues production of the Escort, it is likely to have no effect as to how Ford's remaining portfolio of vehicles will perform. However, if you remove a weapon system like the Milstar Satellite Communications System from the battlefield, you negatively impact nearly every other weapon system in their ability to securely communicate with each other and thereby reduce the overall capability of these systems.

Political Oversight

One of the more unique aspects of weapon systems development acquisition is the impact congressional oversight can have on a weapon systems acquisition program. As provided for in Article I of the Constitution, Congress controls the defense authorization and appropriations process. Congress wields tremendous power during the defense authorization and appropriations approval process. At any point

in this process, Congress can cut, add, or leave requested funding levels unchanged as submitted in the president's budget.

Decisions to cut or add funds to specific weapon systems acquisition programs can have profound effects throughout the entire DoD. For example, if Congress decides to cut $10 million in development funds from a proposed Air Force missile program, decision makers must then back and determine the effects of such a cut (the ability to support strategic goals, interaction with other weapon systems [both Air Force and other services], and effects of schedule delay and increased unit costs) and eventually recommend from which programs funds will be taken.

Congressional actions to increase funding levels can also have negative implications. For example, use the same Air Force missile development program, and instead of cutting, Congress adds $10 million. While this situation is likely beneficial for the missile program, typically what happens is that Congress does not increase the overall Air Force budget by $10 million, therefore forcing tough decisions regarding from which other development programs to take the $10 million in order to support the Congressional request.

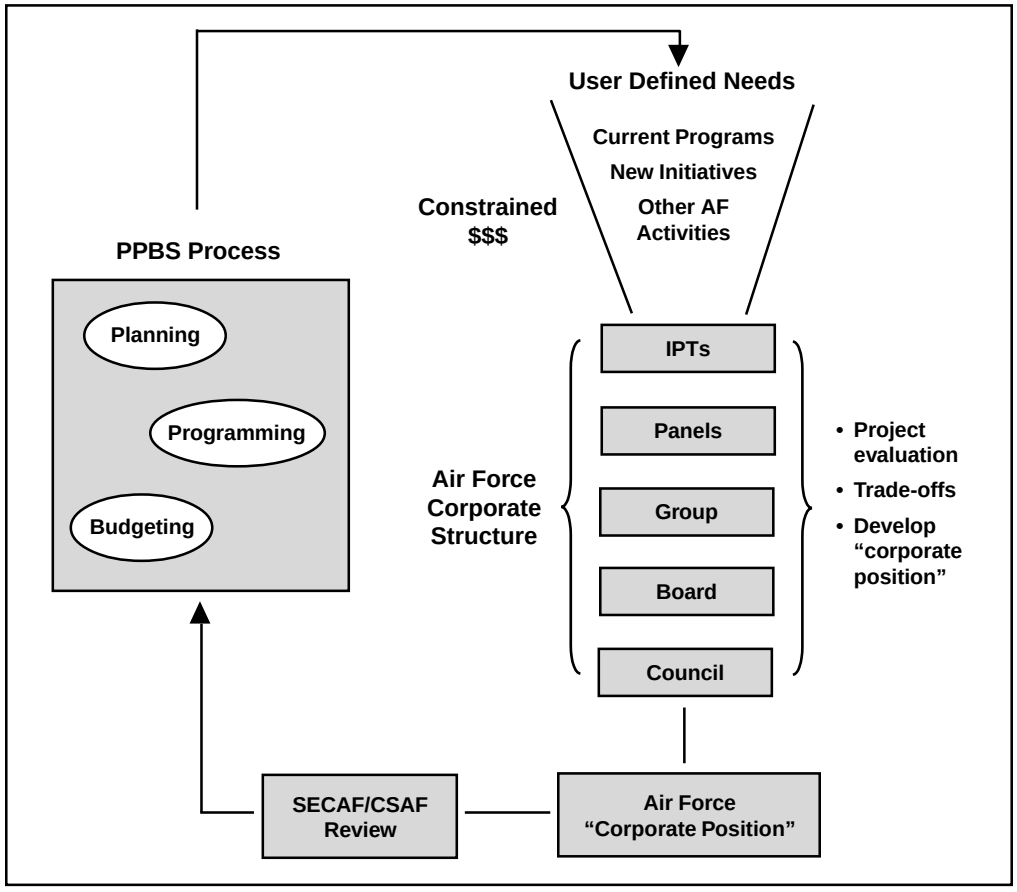

Figure 2. AFCS Decision-making Process Flow

Resource Allocation

The resource allocation process is the focus of this research, and therefore deserves additional introduction. The primary tool used by the DoD in its resource allocation activities is the Planning, Programming, and Budgeting System (PPBS; DoD, 1984). The PPBS is a cyclic process that provides for decision making on future programs and permits decisions to be examined and analyzed from the viewpoint of the current environment — threat, political, economic, technological, and resources. Of particular interest, the multi-functional Air Force Corporate Structure (AFCS) is charged with making decisions regarding resource allocation against all Air Force activities, including weapon systems acquisition programs. Figure 2 provides insight into the flow of the AFCS and how this decision-making body fits within the PPBS process.

"The primary tool used by the DoD in its resource allocation activities is the Planning, Programming, and Budgeting System (PPBS)"

One of the most unique aspects of this resource allocation decision-making process comes in the form of restrictions placed upon the funds allocated during this process. The Department of Defense Financial Management Regulation (DoD, 1993) provides guidance on the use of funds for weapon systems development. Within the DoD, funds are divided into separate categories commonly known as *colors of money*. For example, within the Air Force there are five different categories, or colors, that correspond to a particular activity during the weapon systems development process. These categories and codes include: RDT&E (3600), aircraft procurement (3010), ammunition procurement (3011), missile procurement (3020), and other procurement (3080). Once a weapon system is fielded, operations and maintenance (3400) funds are allocated for support of the system.

In addition to the restrictions placed upon the *use* of funds, funds are restricted in their *lifespan*. This means that funds have to be obligated against contractual agreements within a limited amount of time. However, this restriction does not mean the work has to be completed within this limited time frame. For weapon systems development, these limits range from two years for RDT&E funds, to three years for procurement funds. For example, if the Air Force has a contract with Boeing to build aircraft, the Air Force would use aircraft procurement (3010) funds that would have to be obligated against the contract within three years of the fiscal year of appropriation. Because of the complex technical nature of weapon systems acquisition, at any given snapshot in time, a weapon systems program may be obligating both RDT&E funds and procurement funds that span a wide range of useable lifespan.

Past Research About Commercial NPD and Development Portfolio Management

Identifying and analyzing commercial NPD and development portfolio management best practices has been the subject of many research efforts. While a variety of methodologies have been employed in conducting these research

efforts, a common theme runs throughout — identifying, analyzing, and eventually implementing commercial NPD and development portfolio management best practices can improve an organization's NPD process. Poolton and Barclay (1998) and Griffin (1997) took historical perspectives in identifying commercial NPD best practices. Poolton and Barclay (1998) identified eight major variables and an additional nine key strategic factors found to be critical in successful commercial NPD efforts. Griffin's (1997) research focused on updating the 1990 Product Development and Management Association (PDMA) survey of commercial NPD best practices.

The results indicated practices such as operating under a formal NPD process, developing an NPD strategy and tying that strategy into overall organization objectives, and implementing a multi-functional approach are still important factors for improving NPD success. Calantone et al. (1995) developed a list of 40 fundamental principles for commercial NPD and measured the level of agreement between R&D and engineering practitioners and marketing professionals. Research findings showed a strong overall level of agreement between the two groups. Lester (1998) identified 16 factors within five overarching areas: senior management commitment, organization structure, attractive new product concepts, venture teams, and project management.

Gupta et al. (2000) found that, while both "high-R&D effective" and "low-R&D effective" organizations had similar views on the importance of certain commercial NPD success factors, it is the "high-R&D effective" firms that were more capable of implementing these practices. Scott (2000) took a different approach and through the use of the DELPHI Issues Methodology ranked the 24 most critical problems facing high-tech commercial NPD firms. The top five included: strategic planning, project selection, organizational learning, core competencies, and cycle time reduction. These research efforts will be later used to develop a framework of commercial best practices against which the findings of this research will be measured. As such, the results of past research will be discussed in more detail.

Perhaps some of the most comprehensive research in the field of commercial NPD and development portfolio management has come from the trio of Cooper, Edgett, and Kleinschmidt (1995, 1998a, 1998b, 1999, 2000). Much of their work has centered on conducting extensive analysis of best practices within a vast spectrum of commercial sectors. This group of researchers has been at the forefront of the movement to view the selection and management of development projects as portfolios, much like portfolios are viewed in a financial and investment construct.

"Much of their work has centered on conducting extensive analysis of best practices within a vast spectrum of commercial sectors."

Additionally, their research has resulted in the development of the stage-gate process that calls for a management philosophy that is grounded in the belief that difficult *go/kill* decisions must be made at select points within the NPD process. Cooper et al. (1998b) provided a concise and comprehensive list of practices

required for an effective development portfolio management process.

Research Methodology

Focusing on the exploratory nature of this research, a structured interview (see Appendix) was developed in order to collect data and establish a sound framework for future analysis regarding the effectiveness of Air Force development portfolio management practices. The structured interview contained both open-ended and closed-ended questions. Open-ended questions allowed the respondent the opportunity to provide in-depth insight and discuss a topic in a more unstructured format, while closed-ended questions provided a methodology for confirming common themes emerging from the open-ended questions.

"The structured interview itself was divided into several parts, with a total of 24 questions."

A total of seven closed-ended questions were included in this structured interview and were answered using a five-point Likert scale, anchored by "strongly disagree" (1) to "strongly agree" (5) and a neutral midpoint of "uncertain" (3). The exception to this scale is the question regarding the use of decision support tools, which was anchored by "less than 20 percent" (1) to "more than 80 percent" (5) with 20 percentage point increments in between. Prior to administering the structured interview, a pilot study was conducted with a group of researchers knowledgeable in the area of commercial NPD and development portfolio management. This exercise led to several small refinements and the addition of several questions.

The structured interview package included a brief discussion detailing the research objectives, purpose of the interview process, and bounds of the structured interview. The structured interview itself was divided into several parts, with a total of 24 questions. The first part contains questions designed to collect basic demographic information regarding the respondent. The next section includes questions focused on the strategic alignment of Air Force weapon systems development projects. Additional sections pose questions in the areas of organizational communication, use of decision support tools, feedback processes, identification of risk and uncertainty, determination of weapon system value, and identification of the effects of schedule. A final section allows for the interview subject, in an open-ended format, to identify additional strengths and weaknesses in the Air Force's weapon systems development portfolio management process not previously discussed.

The sample consisted of 25 respondents who, at the time of the data collection process, were involved with the AFCS decision-making process. The sample size, while relatively small, provides a representative view of the AFCS community. Respondents included Panel and IPT Chairpersons, Panel and Integrated Process Team (IPT) members from a cross-section of weapon systems platforms and functional areas, Group and Board members, and other senior Air Force weapon systems procurement policy makers. Respondents were categorized based on three demographic areas: function within the AFCS, primary AFCS level exposure, and

Table 1. Respondent Sample Category Breakout

Function	Exposure Level	Years Experience
Decision Support (14) – 56%	Panel/IPT (8) – 32%	<1 Year (6) – 24%
Decision Maker (7) – 28%	Group and Higher (3) – 12%	1–2 Years (6) – 24%
Policy Maker (4) – 16%	Multi-level (14) – 56%	2+ Years (13) – 52%

years experience with the AFCS decision-making process.

Table 1 provides summary information regarding the breakout of these categories. Decision makers were defined as those who were members of the Group, Board, or Council, or those who were Panel or IPT Chairpersons. Decision support respondents primarily consisted of Panel and IPT members, and a cross-section of weapon system Program Element Monitors (PEMs). Policy makers were defined as respondents who, while actively involved with the AFCS, were primarily focused on the development and refinement of weapon systems acquisition policy. Finally, it should be noted that nearly half the respondents have less than two years of experience with the AFCS, which is typical of military organizations where service members rotate positions frequently.

To ensure a uniform approach to the data collection process, a single interviewer conducted the structured interview. Interviews lasted between 45 minutes and two hours and to increase data reliability, when security conditions allowed, the interviews were audiotaped and later transcribed. Data analysis focused on these 195 pages of transcriptions. Two independent researchers reviewed each transcript using codes and marginal remarks to identify connections and common issues within the individual interview and between respondents (Miles & Huberman, 1994). At the completion of the independent reviews, both assessments were brought together and findings were discussed and eventually synthesized.

It should be noted that the data analysis effort revealed some interesting results regarding responses to the scaled response questions. In many cases, a respondent's assessment to a scaled response question was based on their agreement, or disagreement, with only a portion of the statement. For example, a respondent would "agree" that communication within the same evaluation groups were effective, but would "disagree" that communication between evaluation groups were effective, therefore leading to a misrepresentation in their final assessment of the entire statement. Due to the number of cases in which this communication disconnect seemed to occur, the following discussion regarding research results is limited to the open-ended questions.

Research Results

The following sections address each of the structured interview categories — strategic alignment, organizational communication, decision support tools, feedback processes, identification of risk and uncertainty, determination of weapon system value, and identification of the effects of schedule — and discussion focuses on common themes discovered within the transcripts during the data analysis process. Additional concepts of interest complete the research results section.

Structured Interview Categories

Strategic Alignment. Data analysis indicates that while most respondents understand how strategy is developed and disseminated through the AFCS, more than half (56 percent) of those interviewed believe there is no formal process in place to ensure weapon systems development projects are aligned with strategic goals and objectives. Nearly half (48 percent) of those interviewed cite documents, including the Defense Planning Guidance (DPG), the Air Force Annual Planning and Programming Guidance (APPG), the Air Force Strategic Plan, and Joint Vision 2020, as primary sources of strategic guidance in the decision-making process. Members of the AFCS are briefed and review all strategy documents prior to implementation. One respondent related:

> Documents like the DPG, APPG, vision statements, etc. all provide information as to where we are heading. The AFCS, the Panels and such, are all involved with the review and approval process for these documents, so I think they are pretty educated as to where the Air Force and DoD are heading with strategy.

However, the perception among 13 (52 percent) of the respondents is that there are no formal ties that link projects under consideration back to strategic goals and objectives. A decision maker responded:

> Seems to be big disconnects with what we are supposed to work on, what's our focus, and what should our thrusts be. Doesn't seem to be any links to the Air Force vision.

A respondent involved with the decision support aspect of the AFCS stated:

> I would say the processes that are in place are, arguably, fragmented in how we align individual programs and projects with what's written in, for example Air Force and DoD strategic planning...I would say there is a lack of some kind of front-end analysis, front-end assessment that says, "OK, where and how does this fit and align with the (strategy)?"

Organizational Communication. Under the umbrella of organizational communication, several questions were posed covering subjects such as how strategy was communicated within the AFCS, what information was made available to decision makers regarding development projects under consideration, was the information based on subjective assessments or objective analysis, and how do projects enter the AFCS decision-making process.

When describing what information was made available during the decision-making process, several common themes emerged. With the exception of large-scale weapon systems (large-scale programs versus small programs will be addressed more in-depth later), most decisions are based on limited information and the time frame in which these decisions are made is compressed. Ten respondents (40 percent) expressed concern regarding the issue of limited information, while an additional seven respondents cited concern over the short decision-making time frame.

The Resource Allocation Programming Information Decision System (RAPIDS) database is the primary tool used for presenting information to AFCS decision makers. The RAPIDS database provides a single sheet of information for each project. Information typically includes the estimated cost for the program in each fiscal year, proposed quantities produced in each fiscal year, deltas for both budget and quantities if funds are being taken or increased, the impacts associated with the development project, and where the project ranks on other priority lists. Additional insight into the RAPIDS database is provided by a respondent who stated:

> Within a RAPIDS slide, which captures issues the panel takes a look at and gets briefed up through the process. Within that information it has proposed funding changes and text associated with that. The very first line within the impacts part of that, the individual has to state how that particular project is reflected in the DPG.

In describing their concern over the limited information the RAPIDS sheet provides, a respondent described:

> Typically, we have to put together a couple of lines worth of impact statements…. So you try and capture in one line what the essence of the impact is and you try and put it in terms of operational impact. Sometimes it's pretty far fetched. For example, "being able to conduct an air war" doesn't provide much detail.

Other phrases that captured the issue of limited decision-making information included: "pretty terse statements," "as you get higher up in the process, the depth of information, the volume, gets a lot smaller," and "depending on where they sit, they may not have much information on cost, schedule, and performance available to them."

Comments from a decision maker within the AFCS highlighted the issue of short decision-making time frames and the negative impacts that it can have on a portfolio:

> What happens is that budget bogeys, or budget targets, are given out and you are told that you have 24 hours to come up with an $8 million cut to your program. We peanut butter spread it around.

Additional insight is provided as to the extreme nature of timing and decision-making within the AFCS:

> We are on such a fast track to make the "call" that we may not be able to get all the information needed to assess the impacts…. If the guy at the Air Staff needs to make a call and can't get in touch with someone at the program, then they have to make a guess with their "best-guess-windage."

As a follow-up to the question regarding decision-making information, respondents were asked to discuss whether they perceived the information provided to decision makers to be based more on subjective assessments or based more on objective analysis. Fourteen (56 percent) of those interviewed perceived the information to be more subjective, while seven respondents categorized the information as a combination between subjective and objective. A decision maker described the dual nature of information, stating:

> I think there is a lot of analysis to support a particular position, to try and come to some truth as to where they stand. Then a lot of times there are decisions that have to be made that are not necessarily (objective), you couldn't put them into a cookie cutter, and you have to make some subjective assessments based on the goals and objectives.

Respondents were asked to assess to what extent they perceive new development projects entering the process through the more structured bottom-up approach or those that are directed from senior leadership. Several themes emerged. First, the majority of those interviewed (60 percent) perceived that most new development projects enter the AFCS decision-making process through the more structured bottom-up approach. Seventeen respondents (68 percent) said that anywhere between 60 percent and 95 percent of all new development projects are bottom-up initiatives.

Even though respondents indicated a majority of projects enter the AFCS through the bottom-up process, several respondents expressed the need to secure senior leadership support in order to increase the likelihood for funding allocation. A decision maker in the AFCS process said:

> More successful are those that come through the structured process — bottom-up. Part of the process is you work it up and get acceptance at a high level and then you are allowed to do it. It makes your life a lot easier with high-level support.

Finally, six respondents (24 percent) disclosed some concern regarding the potential for development projects to enter the AFCS process through multiple points. A decision maker who has experienced this recalled:

> We fight through the 15-month budget cycle; defend every dollar; go through a lot of cut drills and agony. Then 14-and-a-half months into the process, someone comes up with a neat idea and it gets briefed to a senior leader. They like it and the hunt for money is on. Usually, money is taken from other programs.

Decision Support Tools. In the context of this research, decision support tools were defined as those products or processes that provide the decision maker with a structured and interactive approach to accessing and interpreting data, with a primary goal of increasing the objectivity within the decision making process. Several questions were asked to gain insight into how decision support tools were implemented within the AFCS decision-making process; what, if any, tools are currently being used and are they used to develop priority rankings or to gain insight into individual projects.

Data analysis revealed several clear themes. First, in nearly unanimous fashion (96 percent), respondents perceived that decision support tools are not used in the AFCS decision-making process. As discussed earlier, tools such as the RAPIDS database are used to organize and present project information but are not designed to aid the decision maker in structuring the decision-making process. Several comments reinforced this lack of decision support tool use within the AFCS:

> Decision support tools — there are none. It's whatever information you can get your hands on and how you use it and how it's presented.

> As far as the AFCS, I'm not sure they are using some of these tools. Nothing that helps in the structuring of the decision-making process.

> I don't think we have good ones. I don't think there really are (good tools), it's what drives you more to the subjectivity on certain things. Because there is a lack of tools to systematically step one through a decision or to do it consistently.

> They view RAPIDS as a decision support tool, and it's just not. No analysis provided…. We make decisions on programs and we don't know what the hell it does. We come to forks in the road and we take both.

When asked to identify whether the tools in place were used for developing ranking priority lists or for gaining insight into particular development projects, there appears to be some variation. While not identified as a decision support aid, respondents addressed to what extent the RAPIDS information database was used. Eight respondents (32 percent) thought that the RAPIDS information slides were used to generate priority- ranking lists, while an additional eight (32 percent) thought the information provided by the database was used to gain insight into the development projects. Still, another eight (32 percent) of those interviewed were adamant that the since the RAPIDS system was not a decision support tool, that neither ranking lists nor project insight was gained through this process.

"Data analysis revealed several clear themes."

Feedback Processes. Questions within this section were designed to better understand which AFCS reviews a development program encounters once it has received

initial funding and is considered an active project. Data analysis indicates some variation, including the identification by several respondents of multiple review paths. The most prevalent are the program reviews conducted by the Program Executive Officer (PEO) function. There are seven PEO offices within the Air Force, each responsible for a portfolio of programs organized under an overarching weapon systems category (i.e., airlift and trainers, space, or command and control). These reviews are conducted on a regular periodic basis.

Within the AFCS itself, a management by exception process was the recurring theme discovered in the data analysis process. Seven respondents (28 percent) described a process where ongoing development projects only return to the AFCS for review when the program is believed to be in trouble. One decision maker said:

"Within the AFCS itself, a management by exception process was the recurring theme discovered in the data analysis process."

> Remember, the AFCS only reviews the deltas to a program. So, once it makes a decision and gives you a certain amount of money and direction to go do, it never goes back and reevaluates your effort until you either need more money or are willing to give some up.

Risk and Uncertainty. The two questions in this section focused on identifying the sources of risk and uncertainty within the AFCS decision-making process and determining how those risks and uncertainties were assessed. For the purpose of this research, uncertainty was defined as the likelihood of an event (either negative or positive) occurring (i.e., a 70 percent chance a weapon systems development project will encounter a cost overrun), while risk was defined as the negative consequences associated when such an event occurs (i.e., when a development project encounters a cost overrun, the potential effects on development schedule and system performance).

Seven respondents (28 percent) identified funding instability as an uncertainty within the process, while an additional five respondent's (20 percent) comments point to concerns regarding the large volume of projects being reviewed by the AFCS decision-making body. It should also be noted, that although previously discussed, the issues of limited decision-making information and a compressed decision-making time frame were highlighted as additional sources of risk and uncertainty by six respondents.

A decision maker described the concern for unstable funding streams, stating:

> We change budgets so dramatically. We don't give a program a budget, sit back, and let them execute. We are always trying to change budgets to account for real world contingencies (i.e., Bosnia) or another program is overrunning costs and finding money to fix that; we don't have a lot of stability.

He goes on to discuss the effects of budget uncertainty on a development program. He described:

> What we do when a program runs into problems, the first response is to cut capability. After a couple of go-arounds, the User comes back and says, "If you cut any more capability out of this program, we don't want it anymore." At this point we have defined the minimum requirements. Then something else happens and we need to slip the schedule a year or two. The end result is a system, which has less capability than the User originally wanted, that was delivered late.

While several different factors emerged as sources of risk and uncertainty within the AFCS decision-making process, it was clear that most respondents were unaware of any process within the AFCS that provided risk and uncertainty assessments. Fifteen respondents (60 percent) cited either they were not aware of such a process or that they believed this responsibility fell upon the program manager. A respondent stated:

> Within the AFCS I don't think there are any. At the program office level, risk and uncertainty estimates, those are all done at the program office. That is totally external to the AFCS. This information doesn't get relayed up to the AFCS, only to other program reviews.

Weapon Systems Value. As previously mentioned, a weapon system's value historically is not measured in economic terms like those in the commercial sector. The questions in this section were developed to gain additional insight into how the AFCS measures weapon systems value. Several recurring themes emerged during the data analysis process. As far as *what* is considered to be a measure of value, ten respondents (40 percent) perceived weapon systems value to be measured by the requirements fulfilled by a particular system, while an additional six respondents (24 percent) view the capabilities a weapon system provided as the primary measure of value for AFCS decision makers. Comments used to describe these measures of value included: "really based on the ability to provide a capability," "what was the capability provided to the User — that is the primary measure of value," "based on the vision, how does the project match up against those capabilities," and "definitely the warfighters value and the requirements."

"As previously mentioned, a weapon system's value historically is not measured in economic terms like those in the commercial sector."

The data also revealed that even though there are perceived measures of weapon system value, the AFCS decision-making activities do not include a consistent process of quantifying or actually measuring a weapon system's value. Eleven respondents (44 percent) reported that there were no techniques or processes for measuring value, and an additional five respondents (20 percent) discussed the subjective manner in which value was determined. In addressing the issue of no techniques or processes for measuring value, a respondent cited:

> I'm not aware of any, believe it or not. I've never seen anything like that, and I've seen a complete cycle. It's subjective, what's on the list, the Chief's (Air Force Chief of Staff) list is a big thing. I never see anything quantitative.

Other comments included: "usually based on a subjective feeling," "mostly based on subjective assessment," and "I can't recall value being addressed too much."

Effects of Schedule. Questions here again focused on determining whether or not techniques or processes were in place to ensure AFCS decision makers understood the effects of schedule changes, either slips or compressions. Data analysis indicated that 12 respondents (48 percent) thought that there were no techniques or processes in place, or that the assessment of schedule change effects were based only on subjective inputs. Several comments highlight the lack of techniques or processes used in understanding the effects of weapon systems schedule changes:

> Everyone understands the effects of slipping schedule, but we do it anyway and don't quantify the results.

> I don't think there are tools; I don't even think it's a process. There is no process.

> No real tools used. Usually based on subjective assessment brought up by the User or the Program Element Monitor.

Additional Concepts of Interest

The following five sections address several additional concepts of interest that were identified during data analysis — failure to integrate, lack of program kill points, cultural aspects, big versus small programs, and budgetary focus. These issues, while unsolicited, are important in accurately describing the current AFCS decision-making environment.

Failure to Integrate. The integrated environment described as a unique factor that distinguished weapon systems development from other commercial NPD activities was discussed earlier. However, 12 respondents (48 percent) expressed concern regarding their perception that the current processes do not take a holistic view into consideration when making weapon systems resource allocation decisions. A respondent stated:

> As far as I can tell there are no models that show those pieces of the Air Force system and what the effect of what one part of the system has on the entire system…. Too often our decisions are based on how does this impact the program, not what does this do to the overall DoD and Air Force mission.

A decision support respondent described decisions being made in a vacuum:

> We tend to measure value in a vacuum. In other words, in this one mission area what's the value of it, and they usually compare it to something that has existed before…. So, when you measure what the value of a weapon system is, we take it in a vacuum,

> we don't look at the rest of the stuff that needs to be brought along with it.

Lack of Program Kill Points. Nearly half of those interviewed described a development cycle where once a development project begins, it rarely is considered for cancellation. Twelve of those interviewed (48 percent) address several drivers behind keeping programs alive even when a program may be behind schedule, overrunning costs, and actual development progress is minimal. These drivers included political influence and the defined requirement for the weapon system. In addressing the requirement issue, a respondent commented:

> The problem is that we just can't kill a program if the need or requirement still exists. We have to look for different ways to solve this need…. I haven't seen many things killed.

Another of those interviewed stated:

> We rarely kill a program; we just stretch programs out because most programs are justified based on a mission need and requirement. The fact that we can't afford it doesn't take away from the valid need and requirement for the system.

A respondent described the effects political influence can have when making decisions regarding whether a program gets cut. He commented:

> Sure, there are people that want to kill programs, but there are jobs at stake, Congressional districts at stake, and there are lots of avenues to get decisions turned around.

Cultural Aspects. Program advocacy, risk averseness, and decision maker experience all were identified to some extent by those interviewed as components to the current AFCS decision making process. Discussion on program advocacy centered on the perception that rather than playing the role of "honest brokers," many involved with the AFCS process were more concerned with securing their program's funding stream. Regarding the role of program advocacy, one of the 14 respondents (56 percent) described this environment, stating:

"The problem is that we just can't kill a program if the need or requirement still exists."

> Every program has a constituency and no matter how bad it's doing it's real difficult to turn it off. The whole emphasis is upon getting your program funded. If you can get your program funded at 40 percent, that's ok, you are in the game and you can fight for future funding to get well.

Seven of those interviewed (28 percent) described a system that seems to be risk averse in nature. Concerns raised included the perception that risk and uncertainty

within development programs is downplayed and the belief that a clear end product must be defined prior to allocation of resources. Further insight is provided by a respondent who stated:

> From an overall view, the AFCS process is risk averse. In other words, if you put forward a program or an initiative that says, "If you invest this much money, you have this chance of getting this return." The response is that if you are unsure about your success, you must not need this money very much.

Finally, 10 respondents (40 percent) addressed the importance that the experience level of the decision maker plays in the AFCS development portfolio management process.

Big Versus Small Programs. Data analysis indicated that many respondents perceived that bigger programs have a clearer path in securing development resources and may in fact hamper the development of smaller programs. Nine of those interviewed (36 percent) described the difference between programs like the F-22, Joint Strike Fighter, and Airborne Laser and small programs, and the effect these differences had on the AFCS decision-making process. A policy maker within the process provided additional insight, stating:

> Sometimes when it involves programs that are near and dear to what the core of the Air Force is all about, in particular I'm thinking F-22s, the premier weapon systems. Those (programs) get a lot of scrutiny, everyone tries to understand the ramifications of those programs. There is more information available, more information flowing. The smaller programs, I'm not convinced corporately they get much insight.

Budgetary Focus. Data analysis revealed that 64 percent (16) of those interviewed perceived the AFCS decision-making process to be driven by budgetary issues rather than specific program issues. When asked to what extent decision support tools were used, a decision maker commented:

> Decision support tools that are used today just check to make sure that you have gotten to the bottom funding line and are within the budget allowed.

Comparison to an Ideal Model of Development Portfolio Management

In order to effectively complete the assessment process, it is imperative that the discoveries made during the data analysis process — the common threads — be compared to an "ideal" model of how development portfolios are selected and managed. As previously identified, past research efforts have focused on defining best practices for both commercial NPD and R&D portfolio management. This effort has been driven by the need to take the first step in understanding current Air Force weapon systems development portfolio management practices. The work of Cooper, Edgett, and Kleinschmidt (1995, 1998a, 1998b, 1999, 2000) has focused primarily on defining best practices for R&D portfolio management. As such, their

Table 2. Comparison of Weapon Systems and Commercial Best Practices

Success Factors	Commercial Best Practices	Air Force Portfolio Management Practices
Strategic Focus (Cooper et al., 1998b; Danila, 1989; De Maio et al., 1994; Griffin, 1997; Hall & Naudia, 1990; Lester, 1998; Liberatore, 1987; Souder & Mandakovic, 1986; Weber et al., 1990; Wheelwright & Clark, 1992)	Corporate goals, objectives, and strategies must be the basis for portfolio selection.	Perception that no process in place to measure project's alignment with strategic goals.
Senior Management Support (Calantone et al., 1995; Cooper et al., 1998b; Danila, 1989; Gupta et al., 2000; Hall & Naudia, 1990; Lester, 1998; Liberatore, 1987; Poolton & Barclay, 1998; Scott, 2000)	Senior management must be closely involved in R&D project selection decisions.	Senior leadership support perceived as a must for development project survival.
Communication (Cooper et al., 1998b; Danila, 1989; Gupta et al., 2000; Poolton & Barclay, 1998; Souder & Mandakovic, 1986)	Must establish good communication links, both internal and external.	Multiple established paths for flow of strategic policy information.
Portfolio Methods and Use (Cooper et al., 1998b; De Maio et al., 1994; Hall & Naudia, 1990; Weber et al., 1990)	Multiple methods incorporated — used to gain insight into each project.	Little to no decision support processes implemented. Primarily budgetary focus.
Flexibility (Calantone et al., 1995; Cooper et al., 1998b; De Maio et al., 1994; Scott, 2000; Weber et al., (1990); Wheelwright & Clark, 1992)	Able to address resource, benefit, and outcome interactions. Adapt to changes in goals, requirements, and project characteristics.	Perceived lack of assessment as to the impacts that portfolio management decisions have on other weapon systems.
Decision Making at Different Levels (Cooper et al., 1998b; Liberatore, 1987; Wheelwright & Clark, 1992)	Must be able to address the organizational structure and the decision-making process involved at each level.	Not directly assessed. Limited decision-making information available and compressed decision-making time frame.
Risk (Cooper et al., 1998b; Wind & Mahajan, 1988)	Risk and uncertainty must be addressed within the selection process.	Perception that risk and uncertainty not adequately addressed during portfolio management process.
Multi-functional Approach (Calantone et al., 1995; Griffin, 1997; Gupta et al., 2000; Lester, 1998; Scott, 2000)	Effective implementation of multi-functional teams in the portfolio management process.	Multi-function evaluation groups at each level of the AFCS. Perception of stovepiping at lower levels (Panels/IPTs).
Customer Focus (Calantone et al., 1995; Gupta et al., 2000; Lester, 1998; Poolton & Barclay, 1998; Scott, 2000)	Needs and requirements of the User assessed during the project selection process.	User's validated need or requirement key driver in portfolio management process.

findings form the foundation of our best practices model. Additional study of past research efforts was conducted, and concepts and success factors that are common among the literature were added to our best practices criteria list. The concepts of process multi-functional approach and customer focus were added to this foundation to develop an "ideal" model. Table 2 frames the comparison between commercial best practices and the results of this research.

Several similarities were discovered during this comparison process. First, both commercial and weapon systems portfolio management practices place great value in the needs and requirements of the User. Second, the Air Force development portfolio management process is structured so that multi-functional representation is the common environment found at each level of the AFCS. Finally, clear paths for the communication of strategic policy and the importance of gaining senior leadership support for a weapon systems development project align closely with those identified as commercial best practices.

"...both commercial and weapon systems portfolio management practices place great value in the needs and requirements of the User."

Perhaps more useful in beginning the process of closing the gap between current practices and commercial best practices is to identify areas where there are differences between the two development portfolio management models. Several such areas were exposed during this research. Perceived practices including limited use of decision support tools; lack of a robust process to assess a project's alignment with strategic goals and objectives; an environment where decision making information is limited and the decision making time frame is compressed; a decision-making process that is perceived to inadequately assess and incorporate risk; and a decision-making process that is perceived to make decisions without assessing and incorporating the impacts to other weapon systems development projects were all identified as areas where the practices of the AFCS do not align with those found among researched commercial industry leaders.

Discussion and Conclusion

Acquisition reform efforts have been key drivers in improving Air Force, and DoD in general, weapon systems development and procurement processes and practices. Such reform efforts have called for the emulation and migration toward a more commercial-like approach to weapon systems development and procurement activities. The findings of this research effort indicate that current Air Force development portfolio management practices are not aligned with those commercial best practices described in the literature.

While this research focused on assessing and describing the "as-is" environment of Air Force weapon systems development portfolio management practices, research results should provide those in leadership positions with a foundation from which the first steps toward process improvement can be identified and developed. Although not all inclusive, potential

process improvement paths include separating the review and evaluation of new initiatives from current ongoing programs and other Air Force resource allocation activities, refining the current decision-making support process, defining methods for increasing personnel stability within the decision-making process, and researching alternative methods for defining and measuring the value of a weapon system.

This exploratory research has provided insights into the AFCS development project portfolio management decision-making process. Developing a better understanding of current Air Force development portfolio management practices and benchmarking them against pertinent commercial best practices is a necessary first step to begin bridging the gap between these two environments.

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Appendix
Interview Questions

Background Information

1. What is your current duty title?
2. How long have you been in your current position?
3. What is your role in the weapon systems development project selection process?

Strategic Alignment

4. What processes are in place to determine a potential development project's alignment with these strategic goals and objectives at the DoD level, the Air Force level, the MAJCOM/CINC level, and the Weapon Systems level?
5. Please assess the following statement: the AFCS decision-making process ensures that a weapon systems development project's capabilities align with the strategic goals and objectives at the DoD level, the Air Force level, the MAJCOM/CINC level, and the Weapon Systems level. *

Communication

6. By what means are the different levels of strategic goals and objectives communicated to decision makers in the AFCS decision-making process?
7. Describe the types of information made available to decision makers in the AFCS regarding the specific development projects under consideration.
8. Based on your assessment, is the information provided to decision makers based more on *objective analysis*, or is it based more on *subjective assessments*?
9. Based on your assessment, what percentage of new development projects enters the AFCS decision-making process via the bottom-up approach versus those that enter the process as an initiative directed by senior leadership?
10. Please assess the following statement: from an overall perspective, the AFCS decision-making process provides effective and efficient opportunities for the flow of development project information within the same evaluation group and between different evaluation groups. *

Decision Support Tools

11. In the AFCS decision-making process, what types of decision support tools are used during the evaluation and selection of weapon systems development projects?

12. Based on your assessment, are the decision support tools that are implemented used more for generating *optimized project ranking lists*, or are they used more for providing *insight into each development project alternative*?

13. Please assess the following statement: decision support tools are used what percentage of the time in the AFCS decision-making process when evaluating and selecting weapon systems development projects. *

Feedback

14. Once a weapon systems project has initially entered the development process, and returns to the AFCS for recurring review, what types of feedback are provided to the decision maker regarding the current status of the development effort?

15. Please assess the following statement: the AFCS decision-making process provides effective and efficient opportunities for feedback to occur regarding the current status of a weapon systems development project under review. *

Risk and Uncertainty

16. Identify sources of risk and uncertainty within the AFCS and discuss the effects that risk and uncertainty have on decision makers and the decision-making process.

17. Identify the tools and techniques currently implemented within the AFCS that provide initial risk and uncertainty assessments inherent in a weapon systems development project.

18. Please assess the following statement: the AFCS decision-making process ensures that risk and uncertainty are identified and assessed during the weapon systems development project selection process. *

Value Determination

19. Identify the tools and techniques currently implemented within the AFCS that are used to determine a weapon systems development project's value.

20. Please assess the following statement: the AFCS decision-making process ensures that a weapon systems development project's value is assessed and considered in the decision-making process. *

Schedule Effects

21. Identify the tools and techniques currently implemented within the AFCS that are used to determine the effects.

22. Please assess the following statement: the AFCS decision-making process ensures that the effects of schedule, either compression or slips, is assessed and considered in the weapon systems development project decision-making process. *

Strengths and Weaknesses

23. What are some additional strengths of the Air Force's current process for evaluating and selecting weapon systems development projects?

24. What are some additional weaknesses of the Air Force's current process for evaluating and selecting weapon systems development projects?

* FIVE-POINT LIKERT SCALE RESPONSE

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